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APPLICATION NUMBER: ***60/411,176***
FILING DATE: ***September 17, 2002***
RELATED PCT APPLICATION NUMBER: *PCT/US03/29650*

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09-18-02 11176 US17A1 PR

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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

INVENTOR(S)		
Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Larry	Reimert	Houston, Texas

☐ *Additional inventors are being named on the____ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

Inner Riser Adjustable Hanger and Seal Assembly

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

☐ Customer Number [ ] → *Place Customer Number Bar Code Label here*

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☒ Firm *or* Individual Name	Browning Bushman P.C.				
Address	5718 Westheimer				
Address	Suite 1800				
City	Houston	State	Texas	ZIP	77057
Country	USA	Telephone	(713) 266-5593	Fax	(713) 266-5169

ENCLOSED APPLICATION PARTS *(check all that apply)*

☒ Specification *Number of Pages*	15	☐ CD(s), Number	
☒ Drawing(s) *Number of Sheets*	7	☐ Other (specify)	
☐ Application Data Sheet. See 37 CFR 1.76			

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT *(check one)*

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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No

☐ Yes, the name of the U.S Government agency and the Government contract number are _____

Respectfully submitted,

SIGNATURE

TYPED or PRINTED NAME Loren G. Helmreich

TELEPHONE (713) 266-5593

Date 09/17/02

REGISTRATION NO. *(if appropriate)* 29,389

Docket Number: DRIA 145-P

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

This collection of information is required by 37 CFR 1.51. The information is used by the public to file (and by the PTO to process) a provisional application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the complete provisional application to the PTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Washington, D.C. 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Box Provisional Application, Assistant Commissioner for Patents, Washington, D.C.

P19LARGE/REV05

Attorney Docket: DRIA-145-P

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN that I, Larry Reimert, have invented new and useful improvements in an

Inner Riser Adjustable Hanger and Seal Assembly

of which the following is a specification:

CERTIFICATE OF EXPRESS MAILING

I hereby certify that this correspondence and all referenced enclosures are being deposited by me with the United States Postal Service as Express Mail with Receipt No. EV 119109648 US in an envelope addressed to the Assistant Commissioner of Patents, BOX PATENT APP., Washington, DC 20231 on September 17, 2002.

By: Wendy D. Marcum

[redacted]

Inner Riser Adjustable Hanger and Seal Assembly

Field of the Invention

The present invention relates to adjustable hangers for use in downhole wells, and more particularly to an inner riser adjustable hanger.

Background of the Invention

In applications such as spars, it is often desired to pull and maintain tension in the production casing when tying-back to the wellhead at the ocean floor. When tying-back the casing to the surface, the casing needs to be in tension due to fatigue, buckling, thermal growth, etc. To put the casing in tension requires that it be tied-off at the surface wellhead.

A selected tensioning mechanism and method may be used to apply tension between the casing and the surface wellhead. When dealing with heavy casing over long distances, the casing tends to stretch. Since the exact amount of casing length stretch is difficult to determine, it is desirable to compensate for this distance by an adjustable load bearing tensioning mechanism. In many spar applications, the tensioning mechanism has an axial stretch length of 3 meters or more. Various types of sealing mechanisms cooperate with the tensioning mechanism to seal between the upper end of the tensioned casing and the wellhead.

Prior patents relating to downhole adjustable hangers and particularly to an inner riser adjustable hanger are 5,566,761; 5,944,111; 4,519,633; 6,328,108;

Prior patents relating to downhole adjustable hangers and particularly to an inner riser adjustable hanger are 5,566,761; 5,944,111; 4,519,633; 6,328,108; RE34,071; 4,938,289; 4,408,783; 4,465,134; 1,546,305; 3,721,292; 4,653,589; 2,660,248; 3,104,708; 3,581,817; 3,690,344; 3,976,139; 2,897,895; 3,011,552; 3,933,376; 4,343,495; 4,674,576; 4,280,719; 4,258,795; 3,861,463; 3,721,292; 1,696,844; 5,299,642; 4,919,454; 6,065,542; 2,228,505; 5,839,512; 4,433,725; and 4,995,464; OTC paper 4576; Adjustable Drilling Riser brochure from ABB Vetco Gray; Publication No. 20010045286; and Publication No. 20020100596.

While various types and styles of inner riser adjustable hangers have been provided to the hydrocarbon recovery industry, prior art inner riser adjustable hangers have significant disadvantages which have limited their acceptance. Those disadvantages include high costs and poor reliability for the sealing mechanism. Many adjustable hangers require rotation of either an inner string or an outer tubular, and in many applications rotation of a string or other tubular at the surface, particularly under conditions where that tubular is subject to high tension and/or rapid changes in tension, are undesirable for the well operator, and in turn may require more costly surface equipment.

The disadvantages of the prior art are overcome by the present invention, and the inner riser adjustable hanger and seal assembly is hereinafter disclosed. The invention also involves a method of maintaining a desired tension in a casing string, and thereafter running in a sealing assembly for sealing between the wellhead and the tensioned casing string.

Summary of the Invention

An adjustable hanger and seal assembly for applying tension to a casing string includes an outer housing or wellhead, a tensioning mechanism, a seal body, an upper and a lower seal assembly, and in a preferred embodiment a C-ring for fixing the seal body to the wellhead housing. The casing string is secured at a lower end within a well and is supported at the upper end by the wellhead housing, with tensioning forces being transmitted through the tensioning mechanism, which may set with the desired tension in the casing string at a selected set position along the length of the tensioning mechanism. The seal body carrying the lower seal assembly and a setting sleeve is subsequently lowered into position with respect to the wellhead, and is then secured in position above the upper end of the casing string. The C-ring moves radially within a locking groove to fix the axial position of the seal body relative to the wellhead housing. The upper seal assembly may then be run into the well, and seals between the seal body and an inner surface of the wellhead housing, while the lower seal assembly seals between the seal body and the casing string.

It is an object of the present invention to improve the reliability of an inner riser adjustable hanger by providing a highly reliable tensioning mechanism that sets the desired tension in the casing string, with the operability of that tensioning mechanism not being affected by a seal assembly. After the tensioning mechanism has applied the desired tension to the casing string, a seal housing with a lower seal assembly may be run in the well to provide a highly reliable seal between the seal body and the tensioned casing string. The upper seal assembly may then be run

into the well to seal between the seal body and the wellhead. The present invention allows for the use of highly reliable seals with few moving parts since the axial adjustment provided by the tensioning mechanism has preferably occurred before these seals are set.

It is a feature of the invention that the seal body may be axially secured to the wellhead housing by a C-ring, so that the seal body may land on a surface of the wellhead housing then be axially secured thereto by the reliability of a C-ring.

It is a feature of the present invention that a support ring may be axially moveable relative to the C-ring for preventing the expanded C-ring from collapsing and moving out from the locking groove in the wellhead housing. It is a further feature of the invention that the C-ring is carried on the seal body and is biased radially outward.

Yet another feature of the invention is the inclusion of a centralizer ring for centralizing the lower end of the seal body relative to the wellhead casing string.

A further feature of the invention is the combination of a detent ring and shear pins to set the lower seal assembly. A plurality of buttons may be used to move the detent ring radially inward, which allows a force to then be transmitted to shear the shear pins and set the lower seal assembly between the seal body and the casing string.

These and further objects, features, and advantages of the present invention will become apparent from the following detailed description, wherein reference is made to the figures in the accompanying drawings.

Brief Description of the Drawings

Figures 1A, 1B, and 1C together depict one embodiment of an inner riser adjustable hanger and seal assembly, with the seal body shown in the landed position and the tensioning mechanism shown in the set or tensioned position.

Figure 2 is a sectional view depicting in greater detail the landed seal body.

Figure 3A depicts in greater detail the left side the tensioning mechanism shown in Figure 1B in the run-in position, and Figure 3B depicts in greater detail the right side of the tensioning mechanism in the set position prior to running the sealing mechanism in the well.

Figure 4 is a half sectional view depicting in greater detail the lower portion of the wellhead housing with the lower seal assembly between the seal body and the upper end of the casing string.

Detailed Description of Preferred Embodiments

An inner riser adjustable hanger and seal assembly 10 according to the present invention provides a mechanism for pulling tension in a casing C (see Figure 1C) positioned within a production riser by using a tensioning mechanism 60, as shown in Figure 1B. The wellhead housing 12 may include multiple locking grooves 14 which allow various styles and types of bodies to land out and be reliably secured to the wellhead housing 12. An upper seal assembly 16 is configured to energize and seal off the annulus between the seal body 18 and wellhead housing 12. The seal body 18 is captured in place by a split lock ring 24 activated to move radially outward into a respective locking groove 14 in the housing 12, with seal assembly 16 energized.

In a conventional manner, a string of casing C as shown in Figure 1 extends down below the wellhead housing 12. At the lower end of the inner tensioning sleeve 62 is a pin connection 22 that attaches to the upper end of the casing string C, so that the casing string is tied-off to the inner tensioning sleeve 62, which is axially fixed by C-ring 64 to the outer sleeve 66, which is secured to the wellhead housing 12. The axially spaced grooves 68 along the inner surface of the sleeve 66 provide numerous locking grooves for engagement with the C-ring 64. The upper end of the wellhead housing 12 may include a connector profile 13 for interconnection to upper equipment E, e.g., a BOP, a tree, or a spool housing. C-ring 24 is supported on the upper end of the seal body 18, and functions as the locking mechanism for the seal body 18 to the wellhead housing. As explained subsequently, the seal body and lower seal assembly 46 carried thereon are

preferably are run in the well with a running tool after the casing string and tensioning mechanism 60 are run in, and after the casing is tensioned to its desired stretch.

Since the bottom of the casing string is tied-off using various slips, hangers, or cement, pick up on the running tool when interconnected with the top of the casing string pulls tension on the string C, so that the stretched casing is set utilizing a running tool RT 1 as shown in Figure 3A. After the desired tension in the casing string is thus reached, the C-ring 64 (see Figure 1B) springs out into a selected groove 68 in the outer tensioning sleeve 66 which is fixed to the wellhead housing 12. To prevent the split ring 64 from collapsing back in and unlocking, the tool slacks off and energizes a support ring 26 that includes portions which move radially inward of and axial aligned with the split ring 64 to back up the split ring. The support ring may include circumferentially spaced downwardly projecting fingers, since a circumferentially complete or full support ring is not required. The entire casing string C is now completely landed and in tension. Most importantly, the casing string has been tensioned to the desired amount, which is very important to the reliability of the threaded connections in the casing joints, and the desired tension is obtained without rotating either the casing string C or the wellhead housing 12. This feature allows tension to be pulled in the casing string with the casing string locked in place without the necessity of any component rotation. A set casing string is fixed in tension by the tensioning mechanism 60, and is shown in Figure 3B prior to running the seal body in the well.

After the first running string and running tool RT 1 are retrieved, the annulus between the seal body 18 and the casing string is sealed by seal assembly 46. A second running tool RT 2 (see Figure 1A) carrying the seal body 18 and the seal assembly 46 may then be run in the well. A setting sleeve 30 supports the seal assembly 46 and is landed on load shoulder 32 of the housing 12. The seal assembly 46 is protected by a centralizing ring 34 located at the lower end of the seal hanger body 18. It is critical that the seal assembly 46 energizes at the proper time. If the seal were to engage prematurely, it could become damaged and thereafter adversely affect sealing reliability and capability. To prevent premature energization, a detent ring 40 (see Figure 2) is supported on the seal hanger body 18, with the setting sleeve 30 being fixed to the seal body 18 by one or more circumferentially spaced shear pins 42. The number and size of the shear pins is a function of the limitations of the housing load shoulder 32. The seal body 18 is thus set above the tensioning mechanism 60, with movement at the setting sleeve relative to the housing 18 controlled by the action of the shear pins 42 and the detent ring 40. The seal body 18, the sleeve 30, and the lower seal assembly 46 are thus preferably run in together on running tool RT 2 after the casing string is tensioned. When the setting sleeve reaches the appropriate load shoulder on the outer housing 12, buttons 44 biased outwardly by springs 45 are pushed radially inward, thereby radially collapsing the detent ring 40 to the position shown in Figure 2. This then allows the shear pins 42 to shear upon a selected load applied by the running string through the running tool RT 2, so that the setting sleeve 30 may land out on the seal hanger and continue downward to set the seal assembly 46

between the seal body 18 and the inner tensioning sleeve 62, which is an extension of the casing string C.

In a preferred embodiment, the inner surface 48 of the seal body 18 is tapered, so that axial movement between the seal body and the seal assembly 46 results in setting the seal assembly to reliably seal between the upper end of the casing string and the lower end of the seal body. In an alternate embodiment, an outer surface of the upper end of the casing string could be tapered to achieve a similar result.

After the seal body 18 has been fixed to the wellhead housing 12 and the lower seal assembly 46 is set, a third running tool RT 3 may be used to lower the upper seal assembly 16 into the well. The third running tool may thus be used to axially move the upper seal assembly 16 from a run-in position to the set position as shown in Figure 1A, so that the set seal assembly 16 reliably seals between the wellhead housing 12 and the seal body 18. The third running tool RT 3 may then be retrieved to the surface so that the combination inner riser adjustable hanger and a seal assembly 10 may be substantially as shown in Figures 1A – C.

The inner riser adjustable hanger 10 of the present invention utilizes large diameter central flow passageways in the seal body 18 and the setting sleeve 30 to allow substantially full bore access to the annulus. More particularly, the diameter of the bores in 18 and 30 are each substantially equal to or greater than the diameter of the casing C suspended from the wellhead housing.

In an alternate embodiment, the upper seal assembly could be run in the well with the seal body 18, and in still further embodiments the upper seal assembly may

be sealed between the seal body and the wellhead housing without requiring axial movement of the upper seal assembly between a run-in position and a set position. An O-ring seal between the seal body and the wellhead housing could thus be used, replacing the seal assembly and the need for a third running tool. A seal assembly 16 as disclosed herein which utilizes axial movement of the seal assembly relative to the wellhead housing is highly preferred, however, since this type of seal assembly provides a highly reliable and long term seal, which is generally not possible with an O-ring seal.

Various types of mechanisms may be used for tensioning the casing string. A preferred mechanism as disclosed herein uses a C-ring to move radially outward into a selected groove to lock the tension casing string to the wellhead housing. The C-ring may be activated, if desired, by a hydraulically powered setting mechanism within the running tool RT 1 which runs the tensioning mechanism 60 with the casing string in the well. In an alternate embodiment, a ratchet mechanism may be used for tensioning the casing string and locking the tensioned casing string to the wellhead housing. Various techniques may also be used to effectively change the length of the tensioned casing string. A threaded nut may be lowered onto a shoulder fixed to the wellhead to change the tensioned length of the string, while in other embodiments an adjustment mechanism which includes rotatable components may be provided below the load bearing shoulder on the wellhead housing. In many applications, however, operators do not prefer to require rotation of a string, since extremely long and relatively expensive threads may be required to achieve the desired tension in the string, and since the threads may be subject to

high load forces and galling. Moreover, the well operator typically prefers not to require rotation of a string at the surface, particularly when the string is subject to high tensile loads. The present invention provides both a tensioning mechanism and a sealing mechanism which do not require rotation of any tubular strings or components within the well.

In a preferred embodiment, the sealing assembly includes an upper sealing assembly which seals to an inner surface of the wellhead housing, and a lower sealing assembly which seals with an inner surface of the casing string. At least one of an upper proportion of the casing string and a lower portion of the seal body preferably includes a tapered surface, such that the lower sealing assembly is moved axially by a setting sleeve to the set position. The setting operation of the lower seal may be accomplished by various alternative techniques and will be apparent to those skilled in the art. As disclosed herein, a lower sealing assembly is preferably provided below the tensioning mechanism, which allows the seal body, the setting sleeve, and the lower seal assembly to be standard for all applications, so that the sealing mechanism will reliably seal the wellhead housing to the casing string regardless of the position of the tensioning mechanism.

The upper seal assembly 16 as shown in Figure 2 is also preferably in the type which is moved from the run-in position to the set position by axial movement of the seal assembly with respect to the wellhead housing. As shown in Figure 2, an outer surface of the seal body 18 is thus tapered to move the seal assembly 16 radially outward into sealing engagement with a cylindrical inner surface of the wellhead 12 when the sealing assembly is moved from the run-in position to the set

position. In a less desired embodiment, the inner surface of the wellhead could be tapered to achieve substantially the same result. The known and fixed position of both the upper sealing assembly and the lower sealing assembly relative to the wellhead housing thus provides high reliability at a relatively low cost.

The foregoing disclosure and description of the invention is illustrative and explanatory of preferred embodiments. It would be appreciated by those skilled in the art that various changes in the size, shape of materials, as well in the details of the illustrated construction or combination of features discussed herein maybe made without departing from the spirit of the invention, which is defined by the following claims.

What is claimed is:

1. An inner riser adjustable hanger and seal assembly for applying tension to a casing string secured at a lower end within a well and supported at an upper end by a wellhead housing, the hanger and seal assembly comprising:

a wellhead housing having a locking groove in an inner surface thereof;

a tensioning mechanism for tensioning the casing string and securing the upper end of the tensioned casing string to the wellhead housing;

a seal body for positioning within the wellhead housing;

a locking member radially movable into the locking groove to fix the axial position of the seal body relative to the wellhead housing;

an upper seal assembly for sealing between the seal body and the wellhead housing; and

a lower seal assembly for sealing between the seal body and the casing string, such that the casing string is tensioned without appreciable rotation of the hanger body.

2. An inner riser adjustable hanger and seal assembly as defined in Claim 1, further comprising:

at least one of an outer surface of the upper end of the casing string and an inner surface of the seal body is tapered; and

a setting sleeve moves axially relative to the seal body to move the lower seal assembly into sealing engagement with both the seal body and the upper end of the casing string.

3. An inner riser adjustable hanger and seal assembly as defined in Claim 2, further comprising:

at least one shear member for interconnecting the setting sleeve and the seal body; and

a detent ring radially movable to allow shearing of the shear member to set the lower seal assembly.

4. An inner riser adjustable hanger and seal assembly as defined in Claim 3, further comprising:

a plurality of circumferentially spaced buttons for moving the detent ring radially inward.

5. An inner riser adjustable hanger and seal assembly as defined in Claim 2, further comprising:

a radial collapsible detent ring; and

one or more shear pins for interconnecting the setting sleeve and the seal body, such that an axial force is transmitted to shear the shear pins to move the detent ring radially inward.

6. An inner riser adjustable hanger and seal assembly as defined in Claim 5, further comprising:

a plurality of radially moveable buttons for moving the detent ring into a collapsed position prior to shearing the shear pins.

7. An inner riser adjustable hanger and seal assembly as defined in Claim 1, wherein the locking member is a C-ring.

8. An inner riser adjustable hanger and seal assembly as defined in Claim 7, further comprising:

a support ring axially moveable relative to the C-ring for preventing the C-ring from moving out of the locking groove.

9. An inner riser adjustable hanger and seal assembly as defined in Claim 7, wherein the C-ring is carried on the seal body and is biased radially outward.

10. An inner riser adjustable hanger and seal assembly as defined in Claim 1, further comprising:

a centralizing ring positioned at a lower end of the seal body for centralizing the lower end of the seal body relative to the upper end of the casing string.

11. An inner riser adjustable hanger and seal assembly as defined in Claim 1, further comprising:

at least one of an outer surface on the seal body and an inner surface on the wellhead housing is tapered; and

the upper seal assembly moves axially relative to the wellhead housing from a run-in position to a set position to seal between the seal body and the wellhead housing.

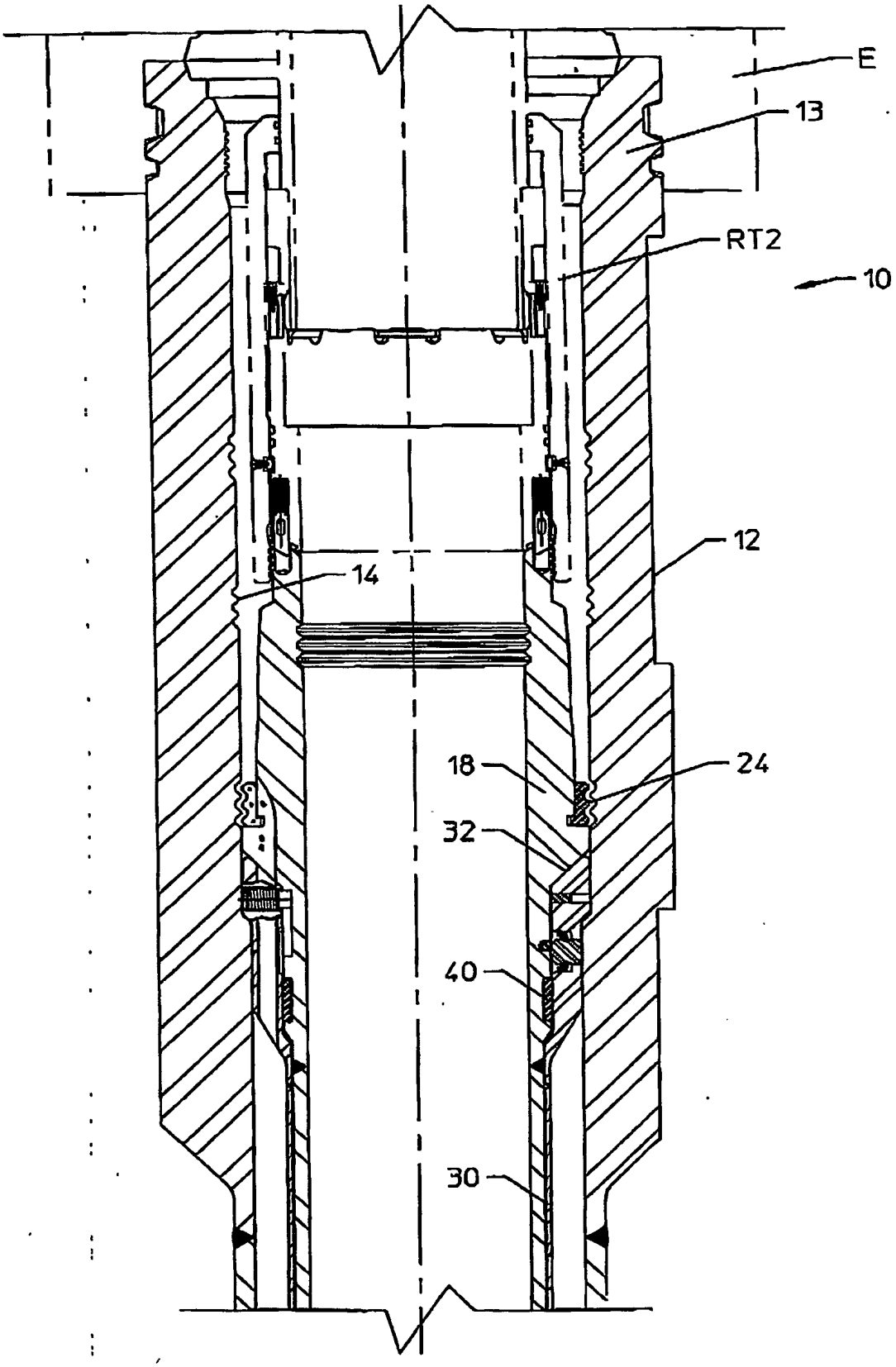

FIGURE 1A

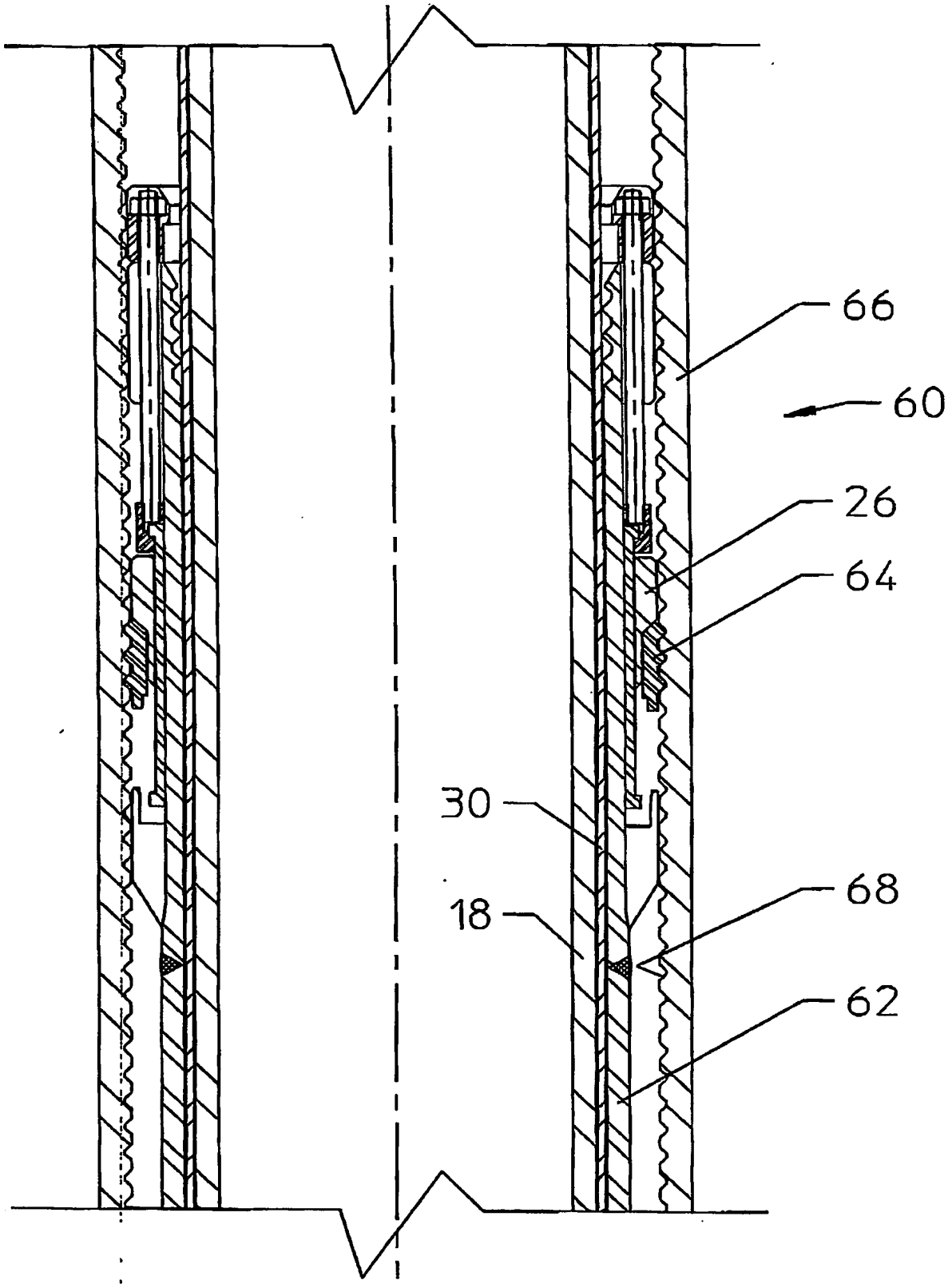

FIGURE 1B

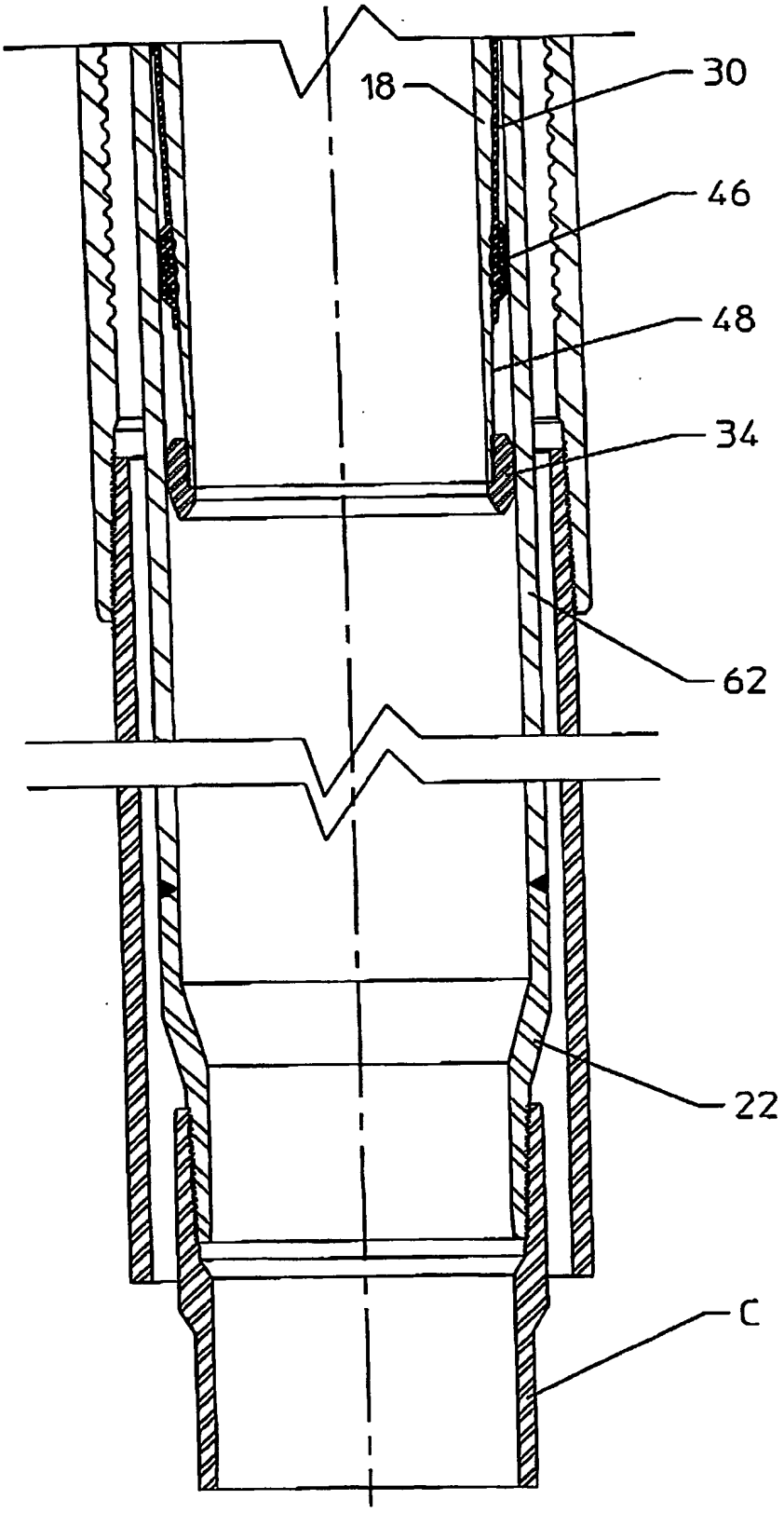

FIGURE 1C

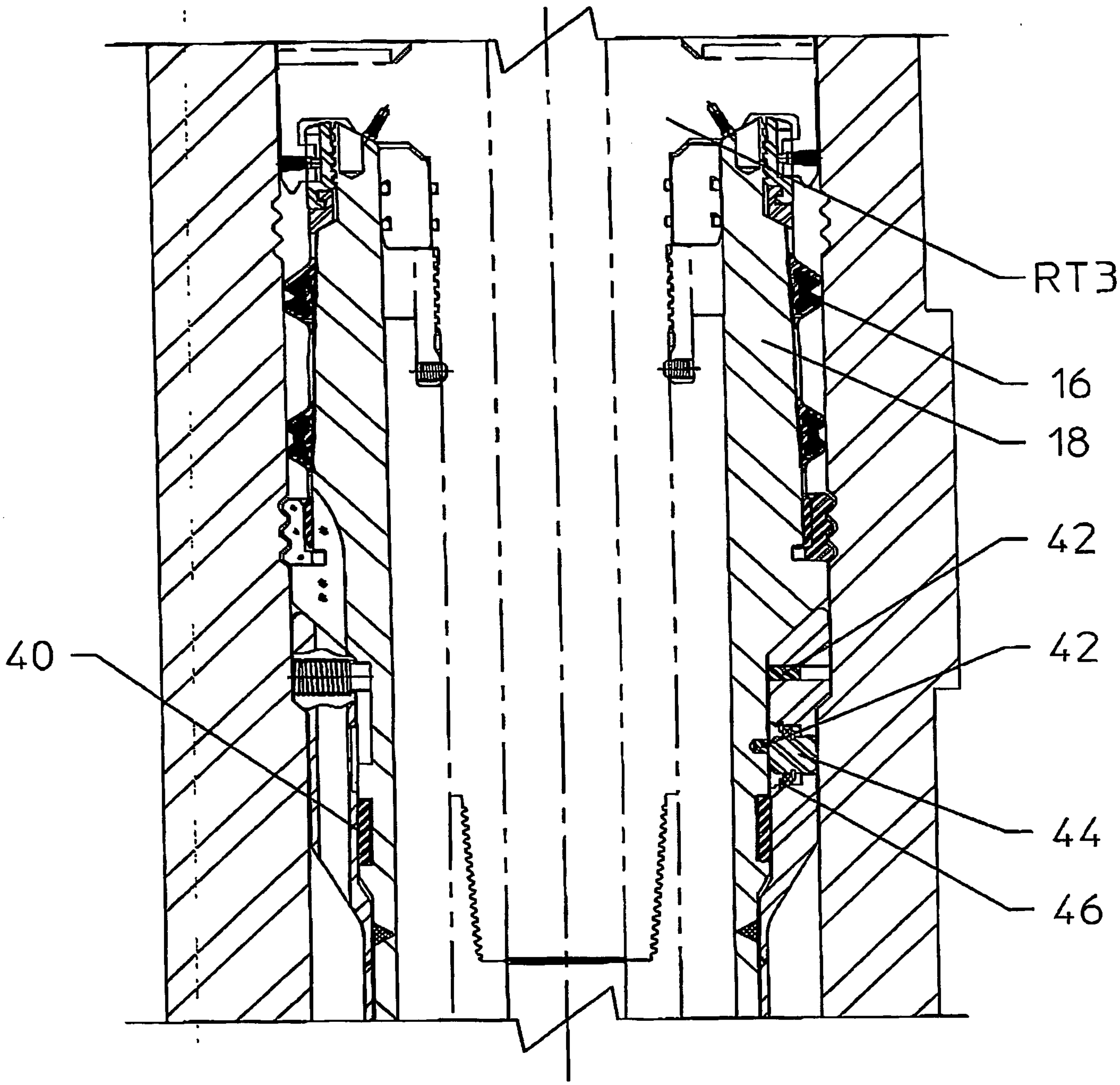

FIGURE 2

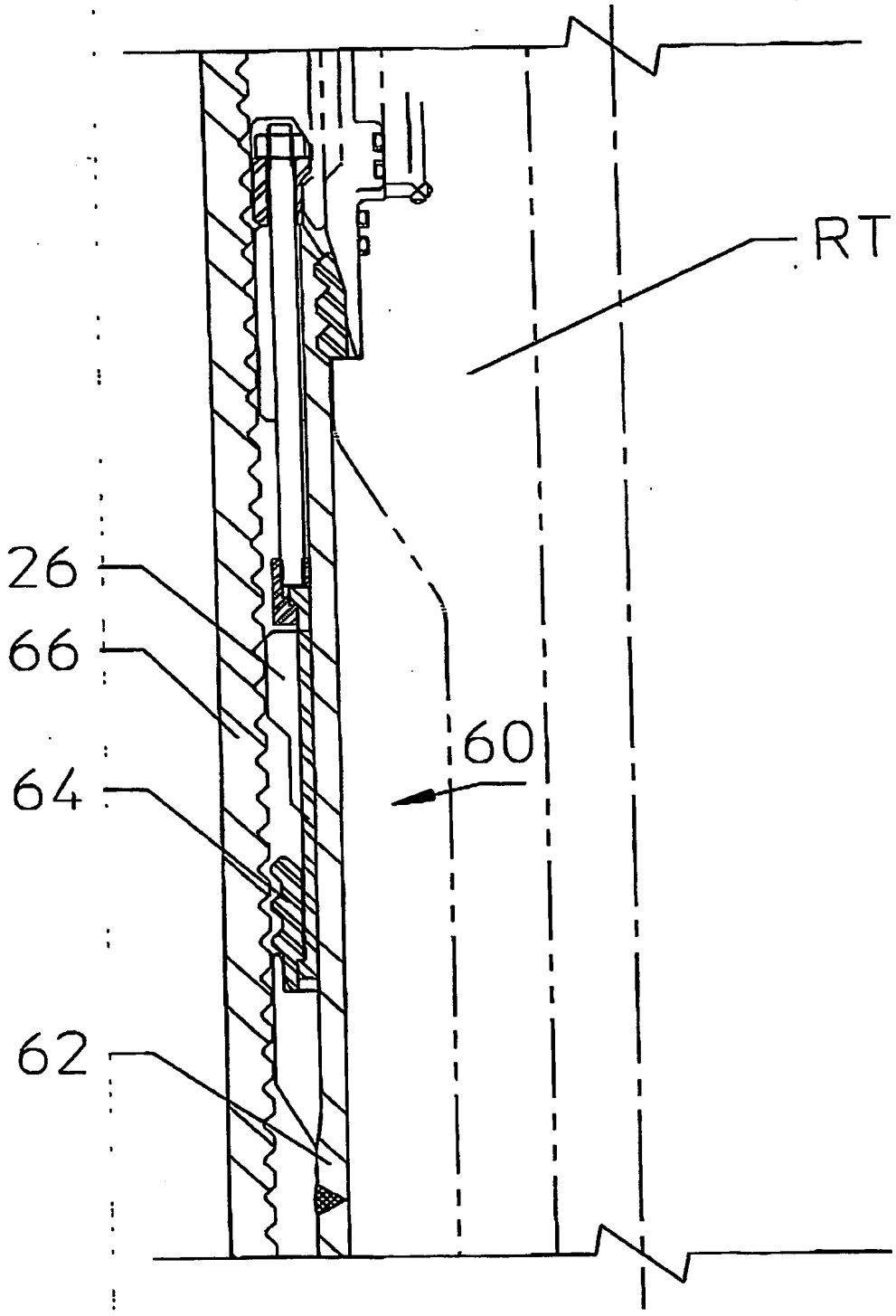

FIGURE 3A

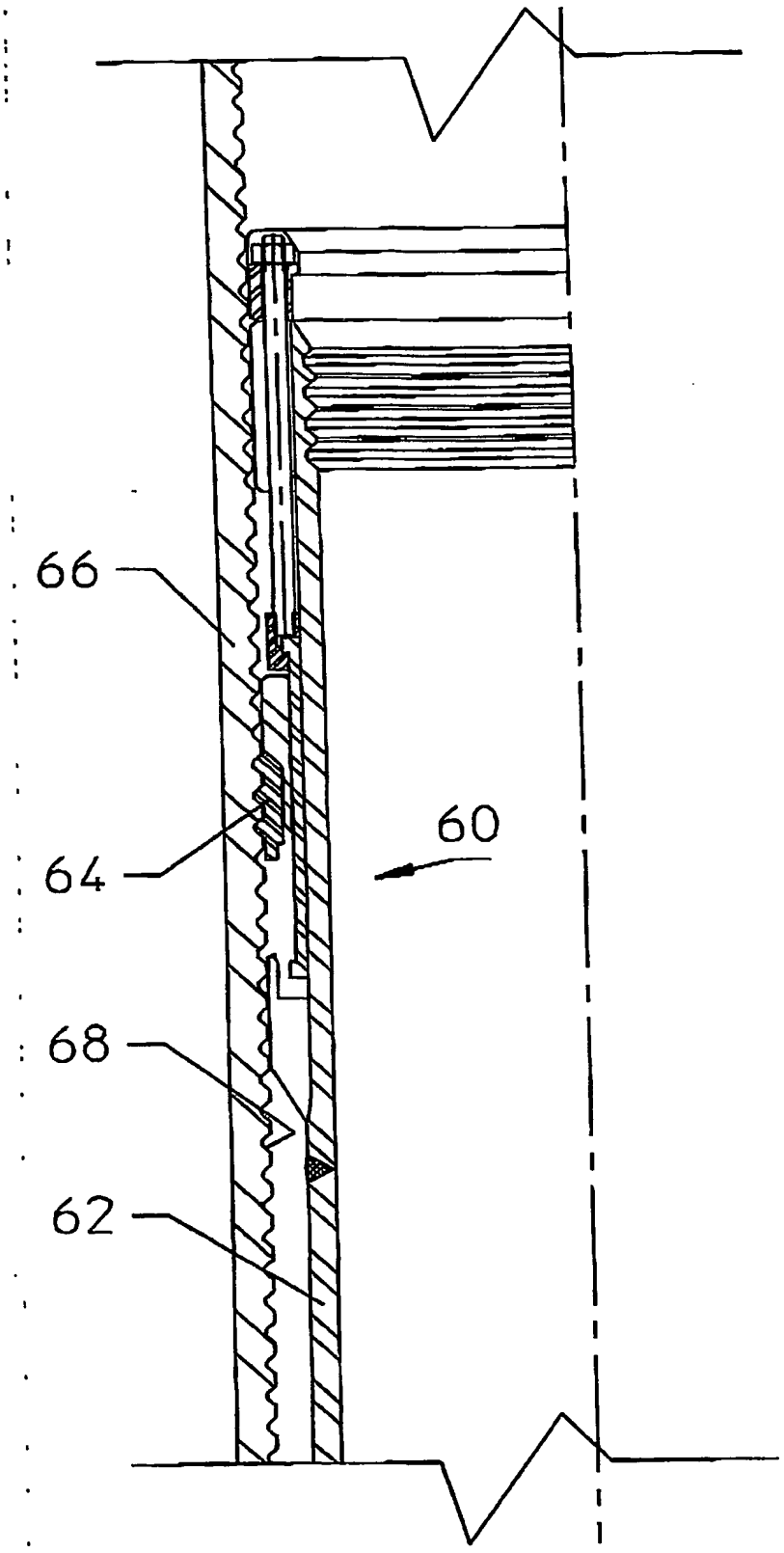

FIGURE 3B

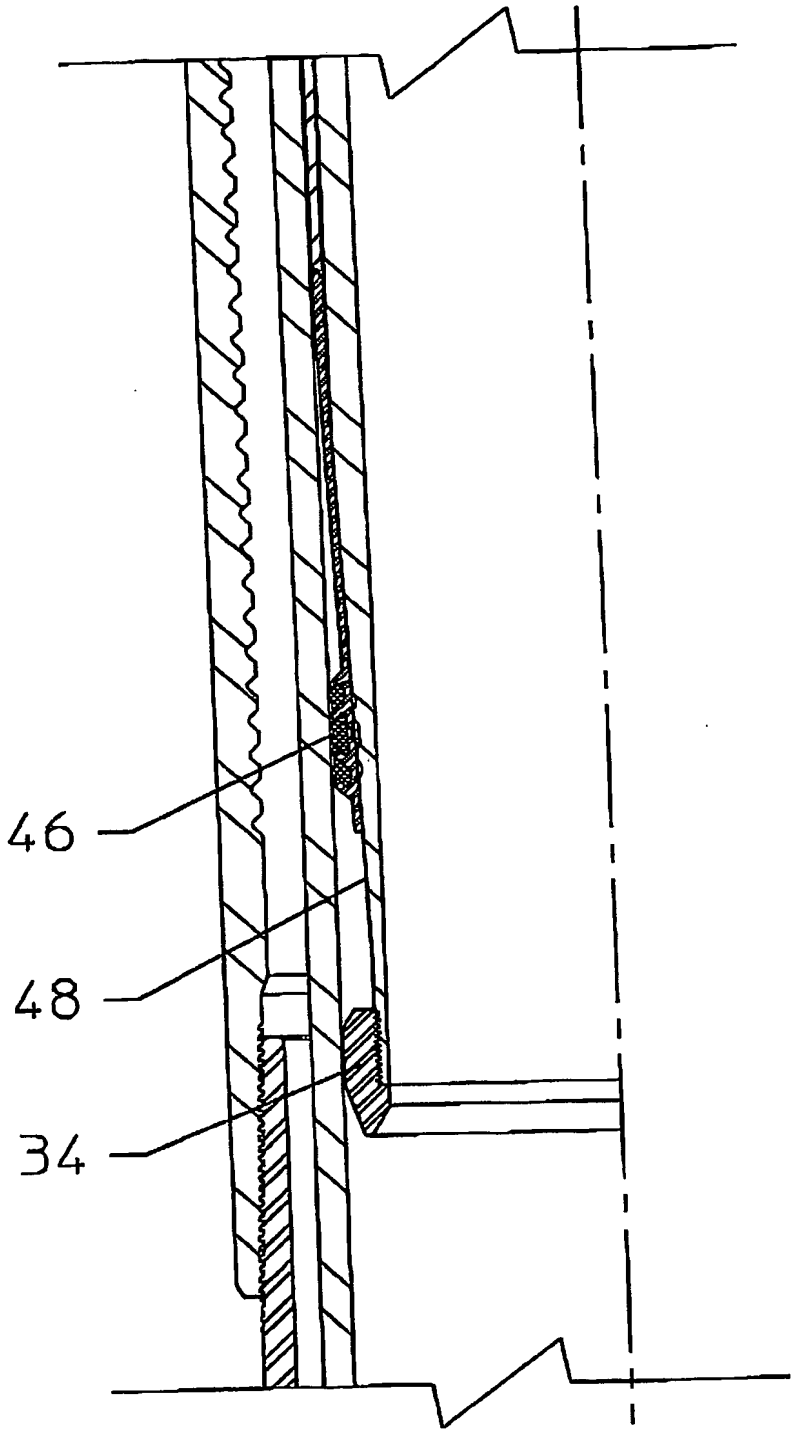

FIGURE 4